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Contextual Enabling or Disabling of Computing-Device Applications and Sensors

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Contextual Enabling or Disabling of Computing-Device Applications and Sensors

Abstract:

Smart devices continue to proliferate and can provide end users with access to a variety of applications that perform a nearly limitless set of functions to assist end users. Each application may access, and leverage, data obtained from a number of sensors incorporated into or accessible to the smart device. Although some applications operate in isolation from one another and are programed to access only certain specified sensors, the experience of an end user could be improved by a machine-learning model that assists separate applications and separate sensors in performing functions together more harmoniously. When an end user initiates a particular application, a machine-learning model may suggest or automatically enable additional sensors that may increase the application's functionality and improve the end-user experience. Likewise, the machine-learning model can suggest or automatically enable a particular application based on the initiation of a particular sensor. The machine-learning-based approach expands the user experience by coordinating and interconnecting the operations of both applications and sensors available on or accessible to computing devices.

Keywords:

Mobile device, user equipment, UE, smartphone, cellular device, tablet, portable device, personal digital assistant, PDA, telecommunication device, wireless device, wireless telephone, laptop, neural network, deep learning, neural net, DNN, CNN, RNN, deep neural network, convolutional neural network, recurrent neural network, sensor, accelerometer, IMU, inertial measurement unit, camera, microphone, audio device, compass, gyrometer, GPS, location service, global positioning system, application, model, tool, software, app, program, utility, activate,

invoke, turn-on, start, make operative, initiate, deactivate, revoke, turn-off, stop, cease, suspend, terminate, operating system, system software, kernel, virtual machine, recommend, suggest, propose, prompt, offer, advise, notify, quantifier, grade, probability, likelihood, rating, percentage, mark, count.

Background:

In general, application developers create applications for smart devices, such as smart phones, tablet computing devices, and the like, that rely on and leverage data from any number of specific sensors integrated into or available to the smart device. These applications are often developed to be run on many devices using a common operating system platform. As such, the application developer may create an application that relies on a sensor not available to a particular device. Alternatively, the application developer may create an application that relies on a generic set of sensors common to all devices. In either circumstance, the end-user experience is diminished because applications remain unconnected to sensors that could provide additional useful data to improve application functionality and increase the usefulness of the sensors themselves. Additionally, the end-user experience could be expanded based on the co-presence and supplementary engagement of particular applications and particular sensors one with another.

Description:

Smart devices continue to proliferate and can provide end users with access to a variety of applications that perform a nearly limitless set of functions to assist end users. Each application may access, and leverage, data obtained from a number of sensors incorporated into or accessible to the smart device. Although some applications operate in isolation from one another and are programed to access only certain specified sensors, the experience of an end user could be improved by a machine-learning model that assists separate applications and separate sensors in performing functions together more harmoniously. When an end user initiates a particular application, a machine-learning model may suggest or automatically enable additional sensors that may increase the application's functionality and improve the end-user experience. Likewise, the machine-learning model can suggest or automatically enable a particular application based on the initiation of a particular sensor. The machine-learning-based approach expands the user experience by coordinating and interconnecting the operations of both applications and sensors available on or accessible to computing devices.

Figure 1 illustrates a computing device including a variety of applications, such as shopping, gaming, calculating, mapping/navigating, and exercising applications, and a variety of sensors, such as a camera, a GPS sensor, a microphone, a heart rate sensor, a motion sensor, and others. The computing device also includes a machine-learning model with a learning-based framework to identify whether a sensor should or could be enabled based on a selected application and whether an application could or should be enabled based on an activated sensor. The machine-learning model is a standard neural-network-based model with corresponding layers required for processing input features like fixed-size vectors, text embeddings, or variable length sequences. The machine-learning model can make cross-application recommendations to a user when the user engages with either a sensor or an application.

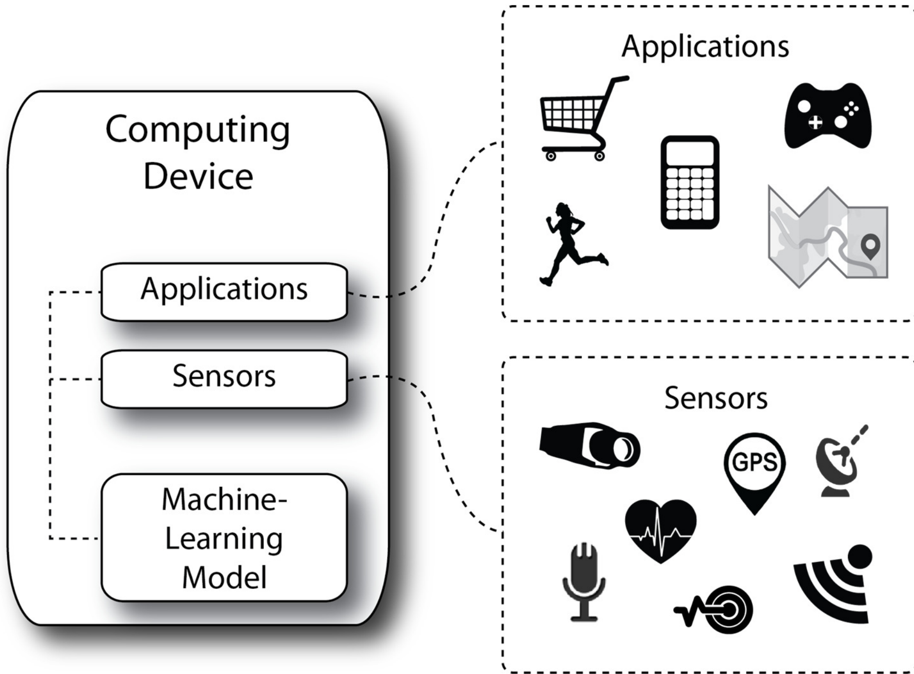

Figure 1

The machine-learning model manages information about registered sensors and applications. Using contextual signals at the operating-system level, the machine-learning model determines a score or rating based on previous user behavior, sensor capability, or application functionality. Above a selected threshold, the operating system can expose the scores as prompts or other recommendations for a user and determine whether a certain sensor should be activated or not. The model is trained using standard maximum likelihood estimation with a target label of on/off depending on the state a certain sensor should have. Once the operating system or the model determines the score, the user can receive the proposed sensor or application activation through an interface and accept a proposed suggestion, refine the default behavior, or override the suggestion of the machine-learning model.

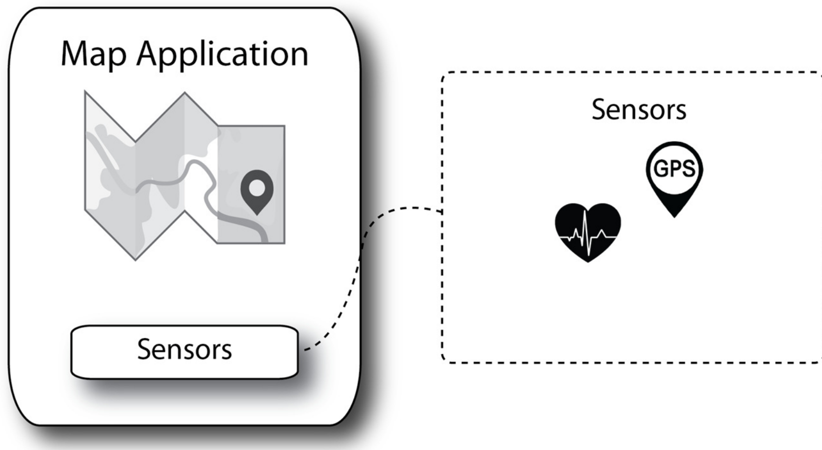

Figure 2

Figure 2 illustrates a map or navigation application. In normal operations, initiating the map or navigation application activates a GPS or other positioning sensor. Other sensors on the device, such as a heart-rate sensor, are not activated or may even be disabled to reduce computing-device computational burdens, conserve battery power, or for other reasons. However, the machine-learning model described herein can suggest modifications to the normal behavior of the map or navigation application. For example, after opening the map or navigation application, the system can monitor a rate of travel of the device. The system can determine that the rate corresponds to a running rate by comparing data or previous running history from a fitness application, which normally would not operate in conjunction with the map or navigation application. Upon determining that the device is moving at a particular rate that corresponds to a running rate for the user, the system can generate a message stating something, such as “It seems that you are running. Would you like to enable the heart rate monitor?” even though this is not a default sensor activated by the map or navigation application. Additionally, the system can monitor the progress of the runner user and only activate the heart-rate monitor at certain key moments, such as during the ascent of a steep hill.

Alternatively, the system can identify contextual clues and prompt a change in the default behavior of an application. For example, a user planning a trip to Paris may be reviewing locations within the city using the map or navigation application but have no need to track his or her current GPS location. The system may alter the default behavior of the map or navigation application and alert the user with a message, such as "It looks like you opened a map application but, because we believe you know your location, we have disabled the GPS to save battery." The user may navigate through a series of menus to achieve the same results, but the system can reduce the number of steps required and handle the request more efficiently.

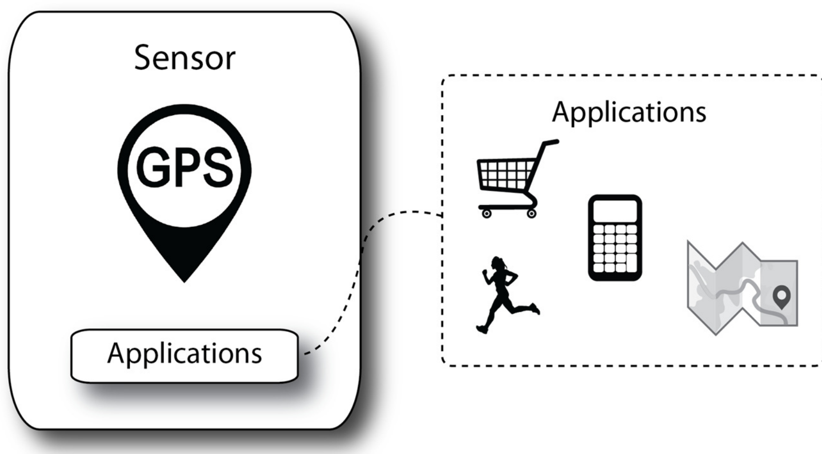

Figure 3

Consider another use of the machine-learning-model-infused system described herein. Figure 3 illustrates the initiation of a GPS sensor, which may happen in the background as the operating system connects to a local cellular base station tower as part of normal operations. Based on contextual information and the GPS location, the machine-learning model may suggest any number of applications to the user. For example, the GPS location may indicate the user is near a shopping establishment noted in a to-do list application and prompt the user to make the purchase or check the list. Likewise, the machine-learning system may start applications in the background that would otherwise need to be started and set up by the users themselves, such as a movement tracking application automatically starting.

Figures 2 and 3 illustrate an iterative process by which a machine-learning model may suggest an application based on the use of a particular sensor or a sensor based on the use of an application. In Figure 2, a user selects the map application, which may automatically engage or suggest the use of the GPS sensor and the heart rate sensor. Nevertheless, the activation of the GPS sensor may itself trigger a secondary set of application suggestions as shown in Figure 3, such as the use of a mileage tracking application or a sales-call logging application. In nearly limitless combinations and perturbations, a machine-learning model can prompt a user to engage in multiple applications with multiple sensors depending on a variety of circumstances, which can increase and improve a user's experience.

As the system accounts for particularities or changes in context, a same application can function in different manners by requesting the initiation of, or disabling of, particular sensors. Consider the man and woman seated at a restaurant as shown in Figure 4. Here, both the man and the woman carry smartphone devices equipped with cameras and video-conferencing applications used in their respective jobs. While at the restaurant, either the man or the woman may receive an incoming call from a client, a potential customer, or a supervisor at their respective jobs. In normal operation, the video-conferencing application automatically engages the camera when the incoming call is received. Nonetheless, the addition of a machine-learning model alters and improves the behavior of the video-conferencing application.

Figure 4

For example, based on an educated determination or estimation of the relationship between the man and the woman, the machine-learning model can override the normal operations of the video-conferencing application. If, in conjunction with information from a calendar application, the machine-learning model determines that the man is at an interview for another job, the system may suggest disabling the camera when the man is given options to answer the incoming call. Likewise, if the man is at an anniversary dinner with his wife at a private restaurant or a restaurant without adequate lighting or sufficient network coverage, as detected by an ambient sensor or wireless network sensor, the system may also suggest disabling the camera. Normally, the man would have to manually navigate a series of menus or settings functions to achieve similar results.

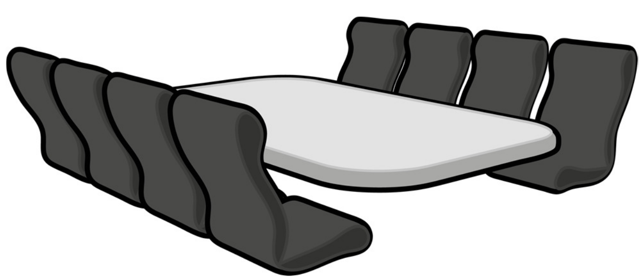

Figure 5

Compare the circumstances of Figure 4 with the conference room setting of Figure 5. Here, assume the man of Figure 4 receives the same incoming call from a long-time client, a potential new customer, or a supervisor but this time he receives a regular telephone call. Based on information from a network sensor or a GPS sensor, the machine-learning system can determine that the man is in the conference room at the office and can suggest the man receive the call on the video-conferencing application instead. The system can also recognize the context of the man and suggest activation of an application to broadcast the call on conference-room hardware, such as an audio/video presentation system, so that everyone in the room is now visible to the caller and capable of participating in the call. Transferring the call to the conference-room hardware may be better than trying to conduct the call around the single speaker or screen of the smartphone or initiating a new call from the audio/video presentation system of the conference room.

Ultimately, the user is in control of the actions taken by the system. As part of the learning, calibration, or control mechanisms of the system, the user may be presented with information and make decisions based on the information. For example, following the use of the map or navigation application of Figure 2, the user can be presented with several different prompts, such as "It appears that you were running. The next time you go running would you like to turn on the heart-rate sensor?" or "It appears that you were running. While running, the heart-rate sensor collected information about your heart. Would you like to view or delete this information? Would you like this information collected in the future?" Likewise, after using the map or navigation application, the user can determine that he or she would have preferred the heart-rate sensor collect information but forgot to turn the sensor or the fitness application on. The user can direct the machine-learning model to prompt, suggest, or automatically engage the heart-rate sensor during the next run. In this manner, the user ultimately retains control over the collection, analysis, storage, and sharing of information collected by sensors and used or assembled by applications of the computing device.

Additionally, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs, or features described herein may enable collection of user information (*e.g.*, information about a user's social network, social actions or activities, profession, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

In many operations, applications and sensors on computing devices function independent of one another. A machine-learning model can assemble contextual information about the computing device or a user of the computing device, including explicit instructions, preferences, or privacy settings of the user. As the machine-learning model more accurately understands context, the model can bridge gaps between operations performed by independent applications and sensors. When a user initiates a particular application, a machine-learning model may suggest or automatically enable additional sensors that may increase the application's functionality and improve the end-user experience. Likewise, the machine-learning model can suggest or automatically enable a particular application based on the initiation of a particular sensor. The machine-learning model expands the user experience by coordinating and interconnecting the operations of both applications and sensors available on or accessible to computing devices.